REMARKS

Applicants would like to thank the Examiner for the thorough examination of the present application. The independent claims have been amended to recite "for factoring a number" in order to overcome the nonstatutory subject matter rejection. Dependent claims are also being added to limit the "number" to an "integer number". Support in the specification may be found in paragraph 22, for example. The claim amendments and arguments supporting patentablity of the claims are provided below.

I. The Amended Claims

The present invention, as recited in amended independent Claim 6, for example, is directed to a method for performing a Shor's quantum algorithm as a function ($f(x)$) encoded with n qubits <u>for factoring a number</u>. The method comprises performing a superposition operation according to the Shor's quantum algorithm over a set of input vectors, and generating a corresponding superposition vector.

The performing comprises calculating as a function of the n qubits a value ($1/2^{n/2}$) of non-null components of the superposition vector, and calculating indices (i) of the 2^n non-null components of the superposition vector as an arithmetic succession, a seed of which is 1 and a difference of which is 2^n. The method further comprises performing an entanglement operation on the superposition vector, and generating a corresponding entanglement vector. An interference operation is performed on the entanglement vector, and a corresponding output vector <u>representing the factored number</u> is generated.

Independent Claim 9 is directed to a method for performing a Simon's quantum algorithm as a function ($f(x)$) encoded with n qubits for factoring a number. The method comprises performing a superposition operation according to the Simon's quantum algorithm over a set of input vectors, and generating a corresponding superposition vector.

The performing comprises calculating as a function of the n qubits a value ($1/2^{n/2}$) of non-null components of the superposition vector, and calculating indices (i) of the 2^n non-null components of the superposition vector as an arithmetic succession, a seed of which is 1 and a difference of which is 2^n. The method further comprises performing an entanglement operation on the superposition vector, and generating a corresponding entanglement vector. An interference operation is performed on the entanglement vector, and a corresponding output vector representing the factored number is generated.

Independent Claim 11 has been amended similar to amended independent Claim 6, and is directed to a quantum gate for performing a Shor's quantum algorithm.

Independent Claim 16 has been amended similar to amended independent Claim 9, and is directed to a quantum gate for performing a Simon's quantum algorithm.

II. The Specification Supports The Claims

The Examiner rejected Claims 6, 9, 11 and 16 based upon the claim recitation of 2^n ($i=1+2^n(j-1)$). The expression in parenthesis is in paragraph 73 of the specification. This expression is not part of the equation, and instead, indicates the values of the index i for which the i^{th} component of the

vector P is non-null. Consequently, the expression in parenthesis in the independent claims has been cancelled.

The Examiner rejected Claims 8 and 15 based upon the claim recitation of $\mathrm{int}[(h-1)/2^n]$. Support in the specification may be found in paragraph 84, which states "the integer part is the function that generates the integer part of its argument." In other words, the "int" truncates its argument.

The Examiner rejected Claims 7, 10, 13 and 18 based upon the recitation of "a value of the non-null components of the entanglement vector being equal to the non-null components of the superposition vector." The Examiner has taken the position that this phrase is not supported by the specification. However, paragraph 80 in the specification supports this recitation. The Applicants submit that the specification supports the claims, and that the above rejections be withdrawn by the Examiner.

III. The Claims Are Directed to Statutory Subject Matter

In a first rejection, the Examiner rejected independent Claims 6, 9, 11 and 16 as being directed to nonstatutory subject matter. Each of the independent claims has been amended to be limited to a practical application. In particular, the independent claims have been amended to recite that either the Shor's or Simon's quantum algorithm is performed as a function ($f(x)$) encoded with n qubits for factoring a number. Support in the specification may be found in paragraph 22. The Applicants submit that the claims are directed to a practical application, such as using Shor's or Simon's quantum algorithm as a function ($f(x)$) encoded with n qubits for factoring a number.

In a second rejection, the Examiner has taken the position that the claimed subject matter contradicts prior art sources. For example, Claims 6, 9, 11 and 16 recite "calculating as a function of n qubits a value ($1/2^{n/2}$) of non-null components of the superposition vector." However, the Niesen reference states that qubit is infinite, which implies that the superposition vector is infinite in length to contain it. The Examiner has taken the position that this leads to the entanglement vector being infinite in length as well.

The Niesen reference states that qubits <u>may</u> assume infinite configurations, but not all these infinite configurations are processed in a quantum algorithm. To factor a number, only a limited number of configurations of an n-qubit are considered. Paragraph 25 of the specification clarifies how the number n of bits (and thus the number of configurations to be considered) is determined as a function of the number N to factor.

In a third rejection, the Examiner states that the claims lack novelty based on the nature of quantum computing and the duration of coherence. The Applicants submit that the claimed quantum algorithms are carried out through operations on vectors and matrices. They may be simulated by a computer or by utilizing hardware quantum gates. They are not carried out by looking at the spin of electrons as in the cited prior art references.

In a fourth rejection, the Examiner referenced Claim 1 which initially recited "Simon's or Shor's" algorithm. In the Preliminary Amendment, Claims 1-5 were cancelled and replaced with Claim 6-19. The currently pending claims

separate out the two different algorithms to different sets of claims.

In a fifth rejection, the Examiner states that generation of the superposition vector leads to a circular argument when the calculated indices of the 2^n non-null components is represented by (P) and the claim also recites the superposition vector, P=f(P). The superposition vector is the vector that will be processed through the entanglement operation. Claim 6, for example, simply defines the operations necessary to determine the positions and the values of non-null components of such a vector. The Applicants do not understand why the Examiner sustains that there is circular reasoning.

IV. The Claims Are Patentable

The Examiner rejected the claims over the Ulyanov et al. published patent application in view of the Cleve et al. published patent application. The Examiner cited Ulyanov et al. as disclosing the claimed invention except for "calculating indices (i) of the 2^n non-null components of the superposition vector as an arithmetic succession, a seed of which is 1 and a difference of which is 2^n". The Examiner cited Cleve et al. as disclosing this feature of the claimed invention. The Examiner has taken the position that it would have been obvious to combine the cited prior art references to produce the claimed invention.

The Applicants submit that the Examiner has mischaracterized Ulyanov et al. Ulyanov et al. is directed to Grover's algorithm - and not to Shor's or Simon's algorithm as

in the claimed invention. Consequently, Ulyanov et al. is not relevant to the claimed invention.

Nonetheless, Grover's algorithm uses superposition, entanglement and interference operations like all quantum algorithms. However, reference is directed to paragraph 296 in Ulyanov et al. - in which they are not the same for all quantum algorithms. FIG. 42 in Ulyanov et al. illustrates a Grover's quantum algorithm simulation including circuit representation and a corresponding gate design - which is different from the Shor's quantum algorithm simulation as shown in FIG. 6 in the Applicant's specification, for example.

Paragraph 512 in Ulyanov et al. refers to FIG. 20 that describes the general structure of an intelligent control system based on quantum soft computing (paragraph 47). Moreover, the mentioned "quantum search algorithm" is the Grover's algorithm (Appendix 4), not the Shor's algorithm.

As for the dependent claims, the function p(y) in TABLE 3.1 on page 11 in Ulyanov et al. is a Probability Density Function, while Pi in equation 6 in the Applicants' specification is a component of a vector.

Paragraph 574 in Ulyanov et al. does not teach how to calculate indices of non-null components of the entanglement vector in terms of an arithmetic succession, but illustrates in FIG. 25 comparison of "GA and QSA structures" (paragraph 50).

It is not apparent why the Examiner states that "Equal" of the Applicants' application is equivalent to "applied" of Ulyanov et al. Moreover, the Applicants do not state that the entanglement vector equals the superposition vector, but that "the value of non-null components of the

entanglement vector equals the value of non-null components of the superposition vector, as it is evident by looking at equations (6) and (7).

The Applicants also submit that paragraphs 317-318 Ulyanov et al. do not teach a memory buffer for storing indices (i or k). Instead, reference in this paragraph is directed to computing P by applying U_P to a register containing the superposition.

Referring now to Cleve et al., it is not apparent where the claim recitation "calculating indices (i) of the 2^n non-null components of the superposition vector as an arithmetic succession, a seed of which is 1 and a difference of which is 2^n" is disclosed. Cleve et al. is directed to simplifying the calculation of the Quantum Fourier Transform, but contrary to the Examiner's position, it does not disclose nor even suggest the Applicants' equation 6.

Even if the references were selectively combined as suggest by the Examiner, the claimed invention is still not produced. Accordingly, it is submitted that amended independent Claim 6 is patentable over Ulyanov et al. in view of Cleve et al. Amended independent Claims 9, 11 and 16 are similar to amended independent Claim 6. Therefore, it is submitted that these claims are also patentable over Ulyanov et al. in view of Cleve et al.

In view of the patentability of amended independent Claims 6, 9, 11 and 16, it is submitted that the dependent claims, which include yet further distinguishing features of the invention are also patentable. These dependent claims need no further discussion herein.

In re Patent Application of:
CALABRO' ET AL.
Serial No. **10/736,237**
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IV. CONCLUSION

In view of the amendments to the claims and the arguments provided herein, it is submitted that all the claims are patentable. Accordingly, a Notice of Allowance is requested in due course. Should any minor informalities need to be addressed, the Examiner is encouraged to contact the undersigned attorney at the telephone number listed below.

Respectfully submitted,

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